CRITICAL REVIEW OF BEACH SAND MINING IN INDIA-WITH PARTICULAR REFERENCE TO CHHATRAPUR SAND COMPLEX (OSCOM) IN ODISHA-A CASE STUDY

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

of

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

BY

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Department of Mining Engineering

National Institute of Technology, Rourkela - 769008

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Under the guidance of

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CERTIFICATE

This is to certify that the thesis entitled **"Critical Review of Beach Sand Mining in India- with particular reference to chhatrapur sand complex (OSCOM) in Odisha-a case study"** submitted by **Mr. Siba Prasad Panigrahi** in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

PROF. H. K. NAIK

Project Guide
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Date:

ABSTRACT

India, bestowed with a coastline of over 6000 km, hosts some of the largest and richest coastline placers. Our beach sand deposits and dunes contain heavy minerals like ilmenite, rutile, garnet, monazite, zircon, and sillimanite. With the help of favorable factors like network of drainage, assisted by wind and coastal processes like tides and currents, have molded the formation of the beach and adjoining dune sands. Ilmenite-rich major beach and dune sand deposits occur in the coastal stretches of Tamil Nadu (Manavalakurichi, Midalam, Vayakallur), Kerala (Chavara), Andhra Pradesh, Odisha and Maharashtra. The ilmenite, found in India, commonly contains 50-60% TiO2 and is favorable for different process technologies. Zircon, Monazite and Sillimanite are omnipresent in both the beach and inland red Teri sands, and constitute potential co-products. The Indian resources of placer minerals are: 348 Million tons (Mt) of Ilmenite, 107 Mt of garnet, 21 Mt of zircon, 18 Mt of monazite and 130 Mt of Sillimanite. Indian resources constitute about 35% of world resources of Ilmenite, 10% of Rutile, 14% of Zircon and 71.4% of Monazite. India meets about 10% of the world requirement of garnet. This unique status is largely due to the exploratory efforts of the Atomic Minerals Directorate for Exploration and Research (AMD) of the Department of Atomic Energy, Government of India. In this project report attempt is made to review the present status and its problems and prospects of sand mining in India. Case studies are carried out and computer programs are developed to calculate certain parameters and reported in this project report.

ACKNOWLEDGEMENT

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I would also like to thank sincerely to Mr. J.N. Sadangi (Manager, Mining) for his guided tour around the mining area at IRE Ltd, Chhatrapur and providing me an insight into the pros and cons of the industry.

I would like to thank profusely to Er. Asutosh Patro for his timely help in developing a software program using C++ language.

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CHAPTER I

INTRODUCTION

1.1. HISTORICAL BACKGROUND

India is bestowed with its mineral deposits especially with a coastline of 6000 km. Heavy mineral deposits of Manavalakuruchi in the state of Travancore (now Tamilnadu) was discovered by Schomberg , a German chemist in 1909 which was proved richer and economical compared to rest of the world .

Interestingly, Mineral sands then mined from rich seasonal Beach washings for only one mineral i.e. Monazite, which produce incandescence by infusing the paraffin mantle in a solution of thorium and cerium compounds, lost its worth due to arrival of filament lamp.

World War I gave the British an opportunity to sieze the German -sponsored company and Schomberg was arrested and sent to Madras. The interest of monazite importers was ceased after 1920. First shipment of illmenite from India was effected in 1922 and production expanded in 1940 contributing nearly 80 % of the world production which is almost 300,000 tonnes.

The Atomic Energy Commission was commissioned in 1948 by Govt. of India. Indian Rare Earths Limited was incorporated as a private company as a joint venture with the then Government of Travancore, Cochin in 1950 under the Indian Companies Act, 1913. IREL became a full-fledged Govt. undertaking under DAE in 1963. OSCOM was set up during 1972, construction had been started in 1975 and mining had been started in 1984.

Main objective of IREL is to emerge as a leading international player in the area of mining and separation of beach sand deposits to produce minerals as well as process value added products. It has mineral processing plants at Tamilnadu, Kerala, and Odisha, Rare Earths division at Alwaye, Kerala and Research center at Kollam, Kerala. Its corporate offices are in Mumbai.

Objectives of this study

1. To review the problems and prospects of sand mining in India
2. Case study of Chhatrapur sand mining complex, Odisha
3. Developing a computer program to address some of the problems

CHAPTER II

LITERATURE REVIEW

2.1. DISTRIBUTION OF HEAVY MINERALS IN INDIAN BEACH SAND DEPOSITS

India is gifted with valuable resources of beach sand minerals. Indian coast-line along Kerala, Tamil Nadu, Odisha, and Andhra Pradesh where significant deposits of different minerals are available is presented below. The important economic minerals are such as -

Ilmanite ($FeO.TiO_2$)

Rutile (TiO_2)

Monazite ($(Ce,La,Y,Th)PO_4$)

Garnet

Sillimanite ($Al_2O_3.SiO_2$)

Zircon ($ZrO_2.SiO_2$)

Varying in size, concentration and grade ranging from 5% to 45%.

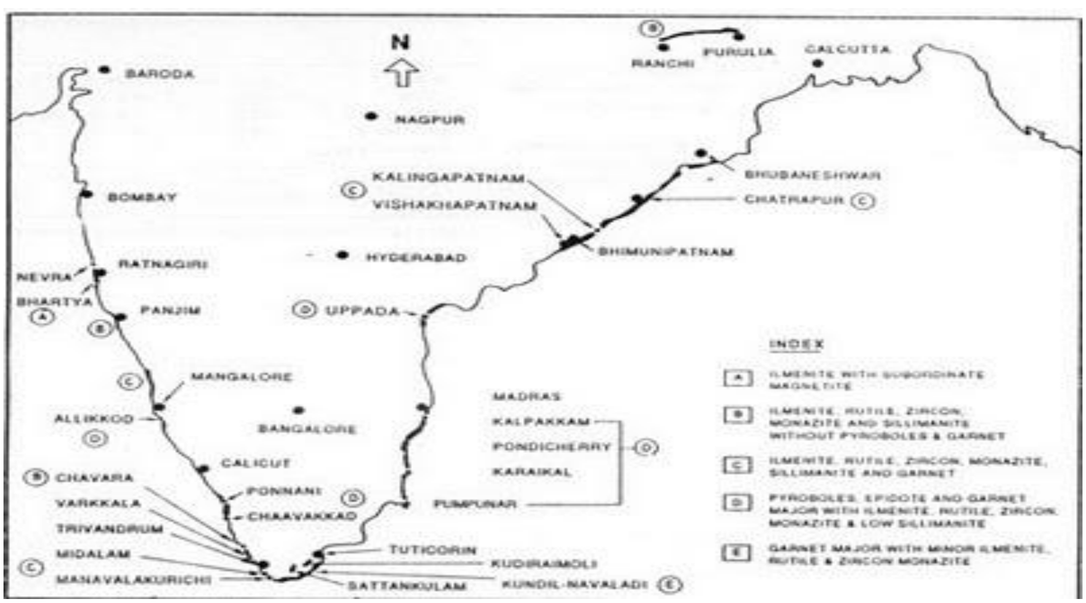

FIGURE 1: INDIAN MAP SHOWING HEAVY MINERAL DEPOSITS

So far estimated Indian resources of placer minerals are **(Mir Azam Ali et al., 2001).**

- **348 million tons (mt) of ilmenite,**
- **107 mt of garnet**
- **21 mt of zircon**

- **18 mt of rutile**
- **130 mt of sillimanite**

According to **Rajamanickam et al. (2004),** of the total global inferred reserves of 1775 million tones of placer minerals, India is bestowed with a reserve of :

- **278 million tons of ilmenite**
- **13 million tons of rutile**
- **18 million tones of zircon**
- **7 million tones of monazite**
- **86 million tones of garnet**
- **84 million tones of sillimanite.**

2.2. FACTORS CONTROLLING FORMATION OF BEACH SAND DEPOSITS

Heavy mineral sands are a class of ore deposit which is an important source of rare earth elements and the industrial minerals such as diamond, sapphire, garnet, and other precious metals or gemstones. Placer deposits are formed usually in beach environments by concentration due to the specific gravity of the mineral grains. Heavy minerals (aside from gold placers) exist within streambeds, but most are relatively small and of a low grade .The grade of a heavy mineral sand ore deposit is usually low. Within the 21st century, the cut-off grades of heavy minerals, as a total heavy mineral (THM) concentrate from the raw sand, in most ore deposits of this type is around 1% heavy minerals, although several are of higher grade. Total heavy mineral concentrate (THM), components are typically for:

Zircon- 1% to 50% of THM,

Ilmenite- 10% to 60% of THM

Rutile- 5% to 25% of THM

Leucoxene- 1% to 10% of THM

Typically magnetite, Chromite, garnet which is trash minerals usually accounts the remaining bulk of the THM content.

The Beach sand minerals are most recently originated minerals deposits. These are originated in southern hemisphere due to continental drifts. Due to motion between different plates and repeated weathering i.e. heating and cooling, cracks are developed in between the rocks and water gets entered into these cracks. Parent rock is subjected to weathering and erosion and transferred along with sea water and finally sediment in a suitable basin. Continued erosion due to air and water takes place and concentration goes on increasing with time.

The source of heavy mineral sands is within the erosional areas of a river where the eroded minerals are dumped into the ocean, thereafter the sediments are caught up in littoral or long shore drift. Rocks are sometimes eroded directly by the wave action and washed up onto beaches and the lighter minerals are winnowed.

The source rocks determine the composition of the economic minerals. Usually granite is the source of zircon, Rutile, monazite, and some Ilmenite. The source of Ilmenite, garnet is ultramafic and mafic rocks, such as kimberlite or basalt. Garnet is sourced commonly from metamorphic rocks, such as amphibolite schists. Precious metals are generally sourced from deposits hosted within metamorphic rocks.

2.3. MAJOR PRODUCERS OF BEACH SAND IN INDIA

- Indian Rare Earths Limited (IREL)
- V.V. Minerals
- Beach Mineral Company
- Transworld Garnet Sand
- Indian Ocean Garnet Sand
- Tata Iron & Steel Company (TISCO)

TABLE -1: FACTORS AFFECTING PLACER DEPOSITS

Event	Effect[1]	Consequences, with implications for the formation and reworking of placers
Tectonic activity	Uplift and tilting	Exposure, erosion of source(s), release, comminution, downslope movement, and dispersal of mineral and sediments (1); peneplanation on erosional unconformities, development of major drainage systems and modification of existing ones with stream headwater migration (2), flow change, and river capture; placer creation, and reworking of existing placers
	Faulting, including block faulting Coastal faulting	Exposure of source(s), influence on and modification of drainage patterns, provision of a residence for placer development in grabens; exposure of existing placers to marine influence
	Subsidence	Modification of drainage patterns, burial of existing placers
	Volcanicity	Preservation of existing placers
Climate change	Arid, and cold or warm	Physical weathering, glaciation, little vegetation and irregular water flow, deepening of valleys, creation of upland flood plains and terraces, and development of placers with large clasts and less dilution
	Humid, and warm or cold	Chemical weathering (intensified when warm), consistently high water flow, strong erosion and maximum transport of sediments, widening of valleys and destruction of terraces, and development of placers with smaller clasts and more dilution; extensive reworking of existing placers
	Cyclic climatic changes.	Alternation of erosional and deposition environments encourages erosion, placer formation (3) and reworking of existing placers
Sea-level[1] changes (4) caused by isostatic and eustatic changes, and by continental dispersal and attraction	Falling sea level[2]	Marine regression, base level falls[3] exposure of present-day continental shelf area to subaerial processes of alteration, drainage development, and erosion, incl. eolian; robbing of existing beach placers; preservation of beach placers above sea level, rejuvenation of erosion, some placer formation and reworking of existing placers, especially in coastal areas
	Rising sea level[2]	Marine transgression, reworking, submergence of existing, coastal, fluvial and other placers, development of overburden on existing placers, especially in coastal areas
	Cyclic sea-level changes (5)	Stillstands, important for mature beach development, formed during falling sea levels; creation of complex, marine placer deposits on present day continental shelf; degradation and aggradation

References: (1) = McLeod and Morison (1995), (2) = Metz (1991), (3)= Sutherland (1985), (4) = Sutherland (1987), (5) = Chappell (1994), (6) =Henley and Adams (1979)

[1] Effects and consequences are localized, not worldwide

[2] Sea levels generally rose more rapidly, especially at the end of a glacial period (3) than when they fell

[3] Maximum base level variation worldwide is ca. 400 m (6)

2.4. MINES ACT, RULES & REGULATIONS RELATING TO BEACH SAND MINING IN INDIA

Acts, Rules & Regulation applicable for beach sand mining:-

- Mines Act, 1952
- MMDR Act, 1957
- Atomic Energy Act, 1962
- Environment Protection Act, 1986
- Forest (Conservation) Act, 1980

- Mines Rules, 1955
- Mines Crèche Rules, 1966
- Mines Vocational Training Rules, 1966
- Mineral Concession Rules, 1960
- Mineral Conservation & Development Rules, 1988
- Indian Electricity Rules, 1956
- Orissa Mineral Rules, 2007
- Metalliferrous Mines Regulations, 1961

These mines are governed by the following Regulatory Bodies:

1. Director General of Mines Safety, Dhanbad
2. Indian Bureau of Mines, Nagpur
3. Director of Mines, Orissa

Acts, Rules and Regulations regulated / enforced by the Director General of Mines Safety are:

1. Mines Act, 1952
2. Metalliferrous Mines Regulations, 1961
3. Mines Rules, 1955
4. Mine Vocational Training Rules, 1966
5. Indian Electricity Rules, 1956

Royalty:

Section 9 of MMDR Act 1957 fixed for a period 3 years

Ilmenite/Rutile/Zircon: 2% of sale price on advolerem basis.

Sillimanite: 2.5% of sale price on advolerem basis.

Garnet: 3% of sale price on advolerem basis.

Monazite: Rs125/tonne (Ad-valorem not applicable)

For non-atomic minerals (Garnet & Sillimanite), sale price = IBM published value + 20%
For atomic minerals (Ilmenite, Rutile, Zircon), sale price = invoice price in case of domestic sale = FOB or CIF price less handling expenses in case of export

Dead rent:
In case of natural calamity, if there is stoppage of production and also there is no stock for sales, dead rent will be paid.

Environmental Protection Act, 1986:
It is also known as Umbrella Act, 1986. Coastal Regulation Zone (CRZ), February, 1991: It is measured 500 m from the appropriate base line towards the land site and 200 m measured towards the sea from high tide line.

TABLE-2: PROVINCE OF COASTAL REGULATION ZONE (CRZ)

CRZ 1	Area which is ecologically sensitive (National Park)
CRZ 2	Prior to 1991, any build-up area around the sea shore
CRZ 3	Generally rural areas, beaches and relatively non-disturbing areas (OSCOM is under CRZ 3)
CRZ 4	Coastal area of island (Andaman - Niccobar)

TABLE-3: HEAVY MINERAL RESERVE (IN MT)

Mineral	World	India	Chavara
Ilmenite	1,722	348	12.7
Rutile	255	18	1.0
Zircon	80	21	0.9
Sillimanite	454	84	2.0

TABLE-4: PRODUCTION AT IREL (IN MT)

Plant	Chavara	OSCOM	Manawalakurchi
Ilmenite	1,54,000	2,20,000	90,000
Rutile	9,500	10,000	3,000
Zircon	14,000	8,000	6,500
Sillimanite	7,000	30,000	-
Zirflor	7,000	-	-

2.5. MINE PLANNING ACTIVITIES

Preliminary Investigation

- Prospecting and exploration
- Deposit evaluation
- Selection of equipment
- Set sequence of operation
- Phased acquisition of land

Current Mining Activities

- Guide operating personnel
- Dredge path planning
- Giving drilling data at closed intervals
- Map showing approach road, power lines, water lines etc.
- Monitor advance rate of dredge and depth of cutting
- Prepare production statistics
- Ensuring rehabilitation of mined out area
- Promotion of ecological aspects with the help of systematic plantation

CHAPTER III

CASE STUDY

INDIAN RARE EARTH LIMITED

3.1. IREL Chhatrapur, Ganjam, Odisha (OSCOM)

On August 18th, 1950 Indian Rare Earths Limited (IREL) was incorporated as a private limited company, jointly owned by the Government of India and Government of Travancore, Cochin with the primary intention of taking up commercial scale processing of monazite sand at its first unit namely Rare Earths Division (RED) Aluva, Kerala for the recovery of thorium.

After becoming a fully fledged Central Government Undertaking in 1963 under the administrative control of Department of Atomic Energy (DAE), IREL took over a number of private companies engaged in mining and separation of beach sand minerals in southern part of the country and established two more Divisions one at Chavara, Kerala and the other at Manavalakurichi (MK), Tamil Nadu.

After a gap of about 20 years, IREL commissioned its largest Division called Orissa Sand Complex (OSCOM) at Chatrapur, Ganjam, Odisha. Today IREL operates these units with Corporate Office in Mumbai and produces/sells six heavy minerals namely Ilmenite, Monazite, Sillimanite, Rutile, Zircon, and Garnet as well as various value added products.

OSCOM was commissioned at a place called Chatrapur about 150 Kms from Bhubaneswar and about 320 km from all weather seaports Visakhapatnam to exploit the huge placer deposit across a mining area of 24.64 km^2 to produce 2,20,000 ton Ilmenite having 50% TiO_2 content and associated minerals like Sillimanite, Rutile, Zircon, Garnet, etc. For the first time IREL ventured into dredging and concentration operation at OSCOM. It is quite efficiently engaged in dredging of the raw sand, its upgradation, drying and finally separation plant. Customers imported illmenite primarily for the production of slag and sulphatable TiO_2 pigment. From 1992, A Thorium plant is in operation at OSCOM to produce 240 tpa mantle grade Thorium Nitrate.

TABLE-5: HEAVY MINERAL RESERVE AT OSCOM

Minerals	*Reserves in India (MT)*	*Reserves in Chatrapur (MT)*
Ilmenite	348.15	45.050
Rutile	17.940	1.880
Zircon	21.120	1.440
Monazite	7.990	1.180
Silliminite	130.310	21.230
Garnet	107.020	32.610

LOCATION:

DIRECTION	LATITUDE	LONGITUDE
Northeast	19º 21’ 30”	85º03’23”
Central position	19º 18’ 33”	84º 58’ 36”
Southwest	19º 15’ 38”	84º 55’ 00”

3.2. GEOLOGY OF THE DEPOSIT

The OSCOM deposit formed along the coast of about 18km long and a width of about 1.5 km is the largest of its kind in India. The height of the deposit varies from 1m to 15m from the surface to water table. It is usually in the form of sand dunes and the highest concentration of heavy minerals at the surface. The concentration decreases with the increase of depth. The land is devoid of vegetation except occasional growth of casuarinas trees which requires less water to grow. The sand deposit is less compact and free from over burden, clay or rock in the frontal dune closer to the sea.

The origin of the deposits belongs to the parent rock available in the eastern and the Western Ghats Mountain ranges which contain these minerals in low concentration. The main sources of rocks are Charnokites, Gnesis, Khondalites, Granites, Laterites and Sandstones etc. A tropical climate with heavy rainfall assists in the weathering process. The liberated minerals transported downward with water and air is deposited at the seashore in an unsorted condition.

Rushikulya River acted as transportation agent for the heavy minerals and deposited it in Bay of Bengal.

TABLE-6: INFORMATION ABOUT OSCOM

1	LOCATION	MATIKHALO VILLAGE, CHATRAPUR TALUK, GANJAM DISTRICT, ORISSA STATE. (LAT. 19 DEGREE 16' NORTH, LONG. 84 DEGREE 33' EAST, HEIGHT ABOVE MSL 17 M).
2	WORKS TERRAIN	PLAIN, SEASHORE
3	CLIMATIC CONDITION MAXIMUM TEMPERATURE MAXIMUM OF MEAN DAILY TEMPERATURE MINIMUM OF MEAN DAILY TEMPERATURE RELATIVE HUMIDITY (MAXIMUM) RELATIVE HUMIDITY (MINIMUM)	THE CLIMATIC CONDITIONS PERTAINING TO SITE ARE GENERALLY AS INDICATED BELOW: 45 DEGREE CELCIUS 32.2 DEGREE CELCIUS 16.6 DEGREE CELCIUS 87% (MAY-JUNE) 65% (NOV-DEC)
4	MEAN WIND SPEED	7 TO 12 KMS (DEC-JAN), 20 TO 30KMS (APR-MAY). A SUPER CYCLONE WITH A WIND SPEED OF 260 KM PER HOUR HIT THE IREL, OSCOM SITE ON 17TH. OCTOBER 1999.
5	ANNUAL MEAN RAINFALL	ABOUT 1210 MM HAVING MORE THAN 80% RAIN FALL DURING THE MONTHS OF JUNE TO OCTOBER.
6	SUSCEPTIBILITY TO EARTHQUAKE	FALLING UNDER ZONE –II AS DEFINED IN IS: 1983. HOWEVER AN INCREASED HORIZONTAL SEISMIC COEFFICIENT CORRESPONDING TO ZONE-IV SHALL BE USED FOR DESIGN PURPOSES.
7	RAILWAYS	THE MAIN BROAD GAUGE LINE OF EAST COAST RAILWAYS CONNECTING KOLKATA AND CHENNAI PASSES AT A DISTANCE OF 7 KM FROM THE BOUNDARY OF THE PLANT SITE. THE MAJOR RAILWAY STATIONS ARE BERHAMPUR AT A DISTANCE OF ABOUT 22 KM AND CHATRAPUR AT A DISTANCE OF ABOUT 6 KM. IREL HAS A PRIVATE BROAD GAUGE RAILWAY SIDING EXTENDING FROM CHATRAPUR RAILWAY STATION TO EXISTING IREL PLANT SITE.
8	SEA PORTS	KOLKATA PORT IS AT A DISTANCE OF 550 KM BY ROAD/RAIL. VIZAG PORT IS AT A DISTANCE OF 360 KM BY ROAD/ RAIL
9	AIRPORT	THE NEAREST AIRPORT IS AT BHUBANESWAR AT A DISTANCE OF 160 KMS BY ROAD. FLIGHTS ARE AVAILABLE TO BHUBANESWAR FROM KOLKATA, MUMBAI ~~AND~~ ,CHENNAI AND NEW DELHI.

The actual sorting and concentration takes place due to two principal agents. A breaking wave takes the foreshore minerals to the beach and the backwash carries the lighter minerals back to the sea. And this to and fro action of waves results in sorting and the concentration of heavy minerals in beach placer deposit. Action of the wind enriches the concentration by blowing the finer and the lighter sand particles. The OSCOM deposit can be classified into two sectors viz. south and north for the purpose of evaluation and presentation of the deposit.

3.2.1. Mining Lease Area

2877.76 Hectares from 21/03/1979 to 20/03/1999

2464.054 Hectares from 21/03/1999 to 20/03/2019

TABLE-7: Properties & Chemical Composition of HEAVY Minerals

Properties	Ilmenite	Rutile	Zircon	Monazite	Garnet*	Sillimanite	Thorium
Chemical formula	$FeTiO_3$	TiO_2	ZrO_2 SiO_2 or $ZrSiO_4$	(La,Ce,Y,Th)PO_4 $ThOU_3O_8$	$A_3B_2(SiO_4)_3$	Al_2O_3 SiO_2 or Al_2SiO_5	$Th(NO_3)_4.5H_2O$
Colour	Black	Black	Reddish	Pale yellow	Pink	Colourless	white
Magnetic Property	Mag	Non-mag	Non-mag	Feebly magnetic	Moderately magnetic	Non-mag	---
Electrical property	Conducting	Conducting	Non-con	Non-con	Non-con	Non-con	---
Specific gravity	4.54	4.25	4.6 to 4.7 4.68	5.25	3.9 - 4.1 4.11	3.20-3.25 3.25	
Bulk density	2.8	2.6	2.88	2.98	2.2 to 2.3	1.88	
Chemical composition (typical)							
TiO_2	50.25	94.5	0.7			0.25	
FeO	34.1				24 to 27		0.005(Fe)
Fe_2O_3	12.76	1.1	0.3			0.4	
Al_2O_3	0.45				20 to 21.5	56.4	
SiO_2	0.8	0.9	31.5		38 to 38.5	36.9	
Cr_2O_3	0.05						
MnO	0.55						
P_2O_5	0.03	0.06	0.1	29.8			
V_2O_5	0.22						
CaO	0.05						
MgO	0.78						
ZrO_2		1.2	65			2.2	
Th	42 ppm						
U	<3 ppm			0.35			0.0005(U_3O_8)
ThO_2				8.2			45.3
Acid insolubles				3.5			
Total oxides				66.7			0.1(REO)
Impurities in product (max %)	Gar-1 Mon-0.1	Zir-1.5 Mon-0.3	Sill-2, Rut-0.5 Mon-0.3		Ilm-4.0	Qtz-4 Mon--0.3	

CHAPTER IV

MINING AND PROCESSING METHODOLOGY

4.1. Basic Unit Operations

The complete operation at Indian Rare Earths Ltd can be broadly classified as:

1. Mining/Dredging & Preconcentration [Dredging & Wet Upgradation Plant (DWUP)]
2. Heavy mineral Upgradation [Heavy Mineral Upgradation Plant (HUP)]
3. Mineral separation [Mineral Separation Plant (MSP)]

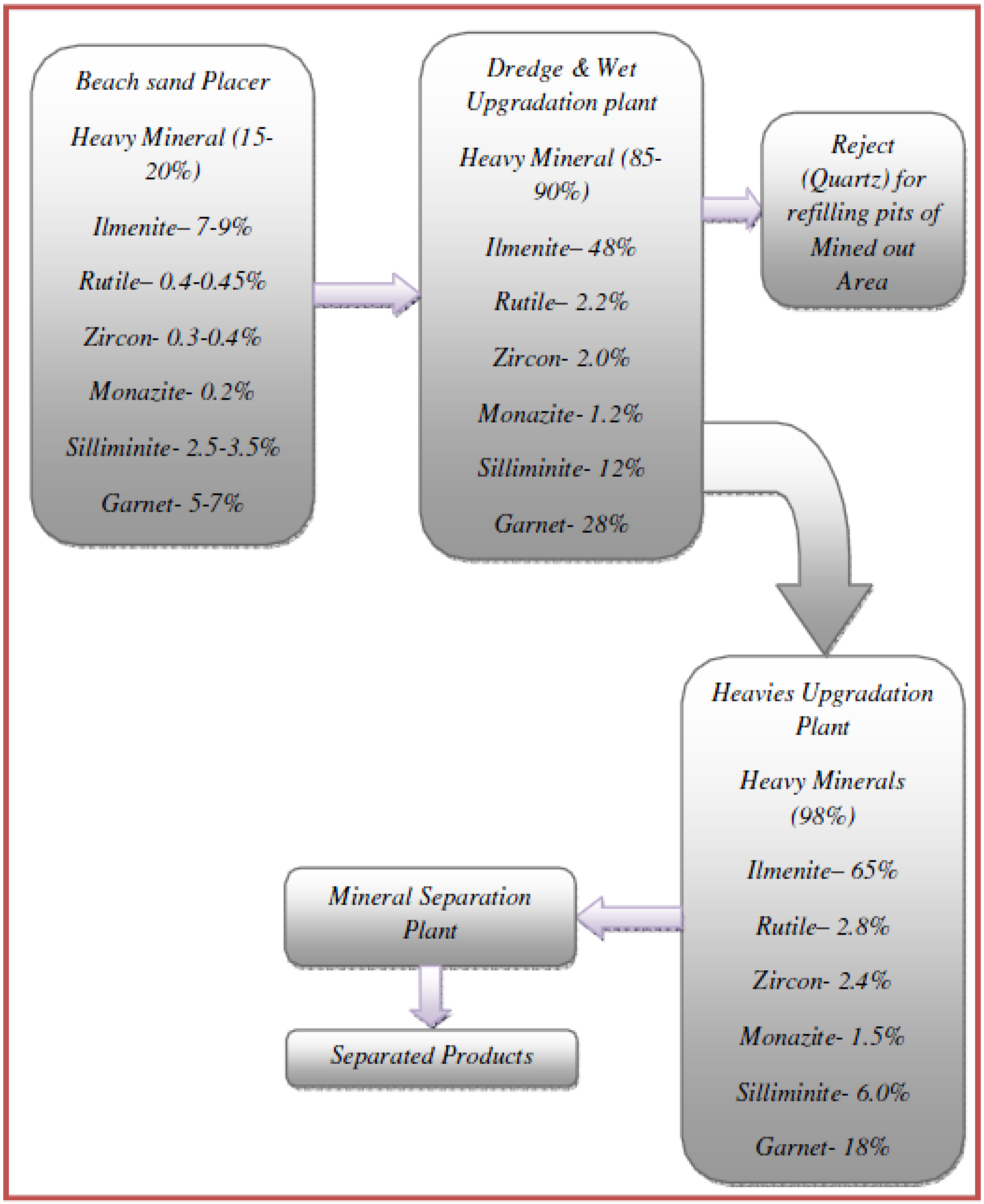

FIGURE -2: PROCESSES OF OSCOM

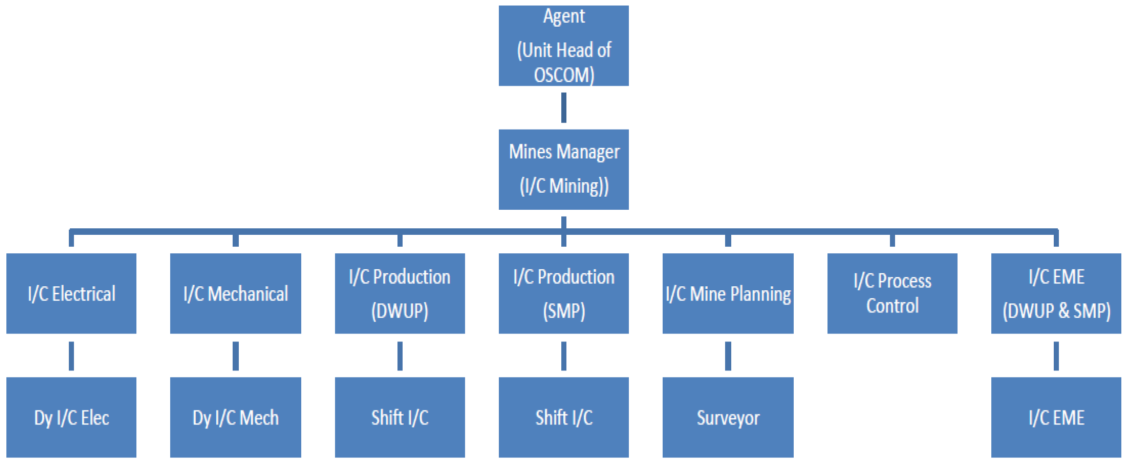

FIGURE -3: HIERARCHY OF OSCOM OFFICIALS

4.1.1. Dredging and Wet Upgradation Plant (DWUP)

The OSCOM have a huge placer deposit with a length of 18 Kms and width of 1.5 Kms running parallel to the coast of Bay of Bengal. Northern boundary of the mining area is Rusikulya River and southern boundary is Gopalpur town. The estimated reserves are 230 MT (1.5m below MSL) and 440 MT (6m below MSL). Mining is divided in two sections; North section and South section. The whole mining area is classified in three zones; plenty zone, Intermediate zone and rare zone.

This plant is in complete floating condition. It floats in a pond having diameter 200m and depth of 6m. The whole unit can be divided in two groups:

1*)* **Mining/dredging**

2) Pre-concentration

Mining:

The mining procedure followed for the excavation of beach sand is completely different from the surface or underground mining. The procedure followed is commonly known as **DREDGING.**

Dredging can be defined as an excavation activity or operation which is carried out at partly underwater, in shallow depth of sea or fresh water areas with the purpose of gathering up bottom sediments and disposing of them at a different location. A dredge is a device used for dredging for scraping or sucking the seabed. A dredger is a boat or ship equipped with a dredge. The process of dredging creates wastes (excess material), which are conveyed to another location different from the dredged area. The dredge Capacity is about 500 TPH and dredge depth is nearly 6m. The RPM of the motor used is 368 with a power of 525KW.In OSCOM, There are two different types of dredge used for dredging purposes:

Cutter Suction Dredge: A cutter-suction dredger's (CSD) suction tube has a cutter head at the suction inlet, used to loosen the earth and convey it to the suction mouth. The cutter can also be used for hard surface materials like gravels or rocks. The dredged material is usually sucked up by a wear-resistant centrifugal pump which is discharged through a pipe line or to a barge. In recent years, in order to excavate harder rock without blasting, dredgers with more powerful cutters have been built.

Bucket wheel Dredge: The bucket-wheel dredge is identical to the cutter suction dredge apart from the position of wheel excavator which is used in lieu of the rotary cutter. In both the cases, the cutter attached to the ladder rotates and cuts the sand and thus make a suspension of sand in water which is pumped out to the Trommel.

Pre-concentration*:*

In this stage, the amount of heavies is upgraded up to 90%. Then it is sent to HUP for further treatment. The suspension formed by the dredger is pumped to the Trommel with aperture size is 4mm, which rotates at 6RPM with a motor power of 37KW. The undersize of the Trommel is sent to bins from where it is sent to the spirals for concentration and the oversize usually containing pebbles, grass and other waste materials. In spirals 4-stage of cleaning takes place i.e. Rougher, Cleaner, Recleaner and Scavenger. Each spiral with 144 starts and each used at 2TPH and the total capacity is 576 TPH. Concentrate from the rougher spirals is sent to cleaner spirals, middlings to Scavenger spirals and tailings to the Hydrocyclone from where the overflow (water) is sent to Trommel discharge and the underflow is the rejects (sand) which is thrown for back filling of the pits. Cleaner concentrate is sent to Recleaner, middlings is recirculated and tailings to the scavenger. Recleaner concentrate is final concentrate which is sent to HUP (Heavy upgradation plant), middlings is recirculated and tailings are sent to cleaner. The scavenger concentrate is sent to cleaner circuit, middlings is recirculated and tailings are sent to Hydrocyclone. By this process the amount of heavies are improved to 90-92%.

FIGURE -4: AJEYA DREDGER AT OSCOM

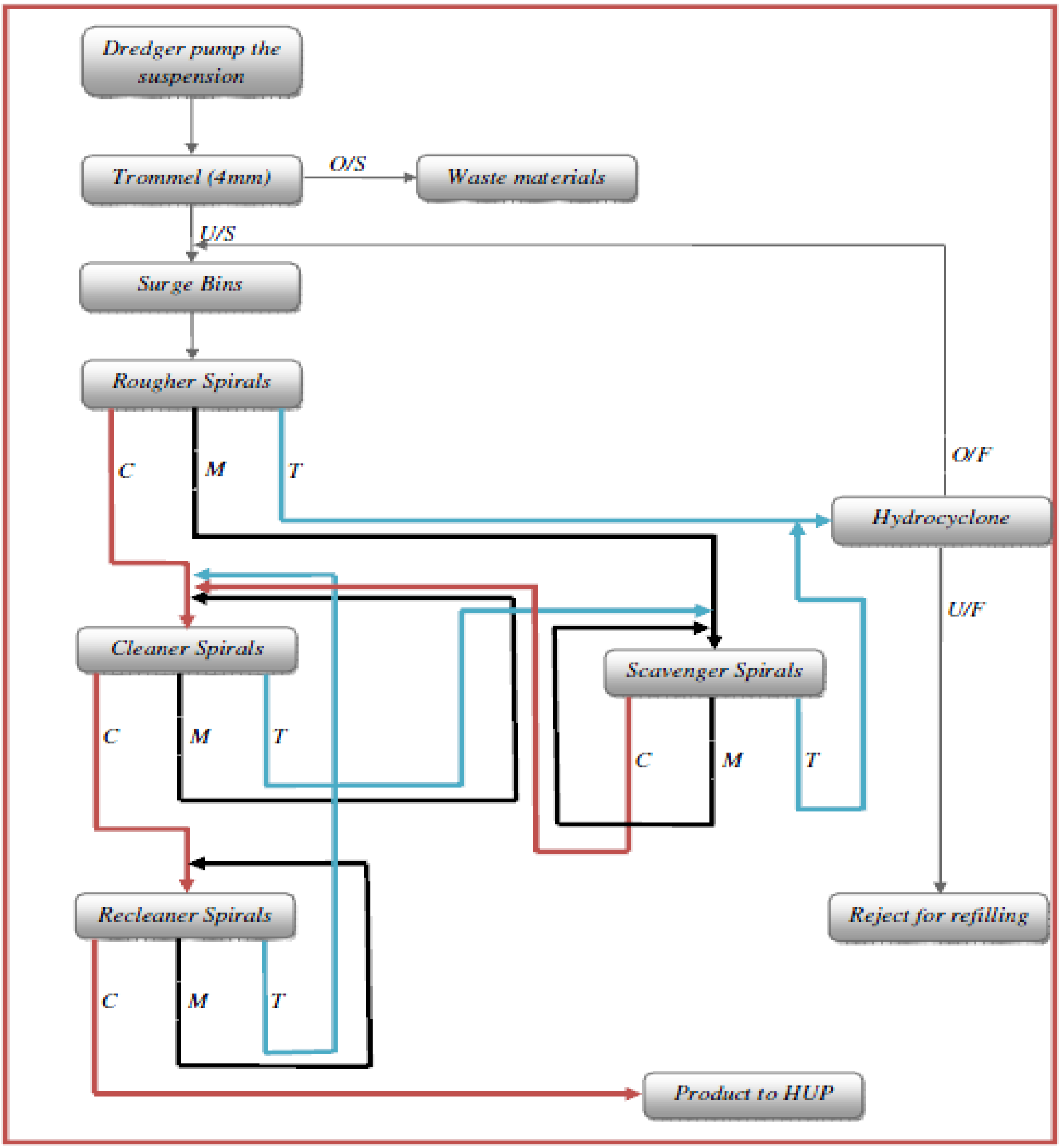

FIGURE -5: FLOW CIRCUIT OF HEAVY MINERAL

Spirals

Spirals are gravity separators where slurry is fed to at a pulp density of about 20-25%, the size range is commonly 3mm to 75 microns and as the slurry flows down the curved channel, lighter particles due to action of centrifugal forces will report to the outer area of the spirals as tails while the heavier particles are pulled inward due to drag force and report to the inner area of the spiral as concentrate, thus effecting the separation. Modern spirals are constructed from fiberglass and plastic and can treat 1-3TPH of feed effectively. The operating parameters are feed rate, pulp density, feed grade, splitter openings, position of distributors, diameter of spirals etc.

FIGURE -6: PHOTOGRAPHS OF SPIRALS

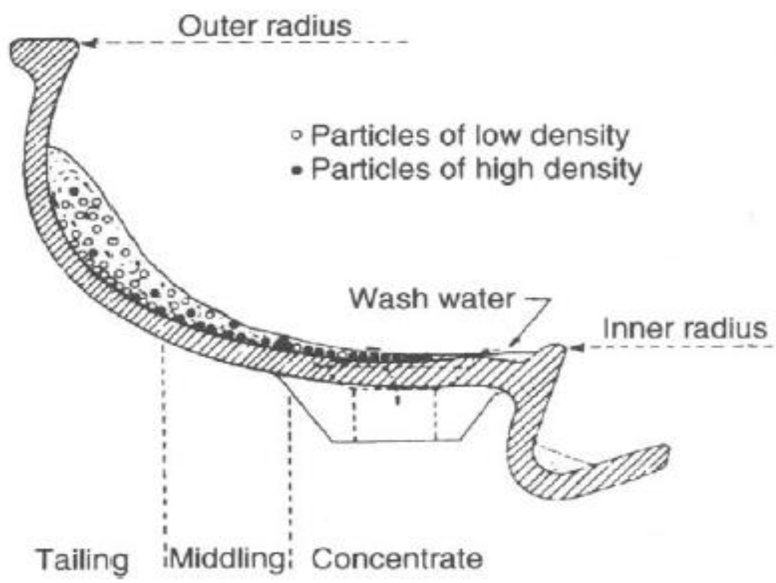

FIGURE-7: PRINCIPLE OF SPIRAL

TABLE-8: SPECIFICATION OF SPIRALS

Sl. No.	Spiral	Type	No. of Distributors	Type of Distributor	No. of Spirals	No. of Starts in each Spiral	Total No. of Starts
1	Rougher - I	HG-7E, HG-8, 8E	4	Open	48	3	144
2	Rougher - II	HG-7E, HG-8	4	Open	48	3	144
3	Secondary Rougher	HG-7E, 8E	4	Open	48	3	144
4	Cleaner	HG-8, 8E	4	Open	48	3	144
5	Re-cleaner	HG-8	4	Closed	32	3	96
6	Pre-HUP Primary Rougher	HC-8000	2	Open	16	3	48
7	Pre-HUP Tails Scavenger	HC-8000	1	Open	8	3	24
Total			**23**		**248**		**744**

4.1.2. Heavy Upgradation Plant (HUP)

This is the stage where the concentration of heavy is further upgraded to 98%. The feed to HUP plant is the Recleaner concentrate of the DWUP where heavy minerals concentration is 90-92%. The heavy minerals are received from Dredge and Wet upgradation plant (DWUP) at the Re-pulping area of Mineral Separation Plant (MSP). These materials are pumped for up gradation in heavy Upgradation Plant (HUP) at MSP. When HUP is not in operation the material is stockpiled at RPA. These accumulated heavies are pushed for pumping to HUP be the help of Earth Moving Equipments (EMEs) whenever required. In HUP, the feed is treated in gravity separation equipment like spirals and Hydrocyclones and the unwanted lighter material is pumped to reject dumping yard and the upgraded heavy mineral is pumped to the dry feed yard through Hydrocyclones for natural dewatering and finally it is fed to main plant by EMEs for drying and further separation.

TABLE -9: MINERAL SPECIFICATION AT HUP

Minerals	HUP Output Minerals Percentage	HUP Reject Quality
Ilmenite	65 – 68%	6 – 7%
Rutile	2.6 – 2.8%	0.6 – 0.7%
Zircon	2.5 – 2.7%	0.4%
Monazite	1.5%	0.05%
Sillimanite	6.5 – 7%	22 – 24%
Garnet	15 – 17%	39 – 40%
Quartz	2 – 3%	25 – 27%
Other	0.5 – 0.6%	2 – 3%

4.1.3. Mineral Separation Plant (MSP)

In the mineral separation plant (MSP), the heavy minerals like Ilmenite, Rutile, monazite, zircon and Silliminite are separated from the upgraded feed minerals on the basis of their physical properties like electrostatic & magnetic property, surface characteristics and specific gravity. The plant comprised of different floor and equipped with different material handling equipment like bucket elevators, belt conveyors, screw conveyors, drag conveyors to facilitate smooth transport of materials to the desired machines for example Rotary Dryer, High tension separators, Magnetic separators, Shaft dryers, Electrostatic Separators etc. Beside this, there is a wet processing circuit which comprises of Spirals, Floatex, Wet Tables, Flotation cells etc and Slurry Pumps are used to transport materials from one point to another.

Annual Production Capacity of MSP

Ilmenite: 220000 TPA
Rutile: 7400 TPA
Zircon: 5000 TPA
Sillimanite: 8000 TPA
Monazite: 2350 TPA

Ilmenite Circuit

The first activity in the MSP includes the drying of the feed material by rotary dryer of 50TPH capacity using Furnace Oil. In the next operation, the bone dried feed (140-150oC) material is fed for High Tension Separators (HTS) where conducting minerals like Ilmenite and Rutile are separated from non-conducting minerals like Zircon, Monazite, Garnet and Sillimanite. Then, the conducting part is fed to Induced Roll Magnetic Separators (IRMS) and Ilmenite being magnetic, separated out from nonmagnetic Rutile and stored in Ilmenite ware house. For further recovery of the products, the middling fraction of High Tension Separator and IRMS are treated in Shaft Dryers followed by HTS, Electrostatic Separators (ESP), Rare Earth Drum Magnetic Separators (RED) and IRMS etc.

Rutile Circuit

The Rutile has conducting and nonmagnetic property is being produced by treating the nonmagnetic fraction of IRMS, REDs etc in Rutile circuit consists of a shaft dryer, HTS, EPS, High Intensity Induced Magnetic Separators (HIRMS), Cross Belt magnetic Separator (CBMS) and vibratory screen etc. Then the Rutile product from the circuit is collected in hoppers followed by bagging in 50kg bags in ware house.

Monazite Circuit

The non conducting fraction is fed to HIRMS followed by REDs to separate the feebly magnetic Monazite and magnetic Garnet from it. Then Garnet part is sent to the reject yard along with the HUP rejects. For further recovery of Monazite from feebly magnetic fraction is treated in Semi Lift Magnetic Separators (SLMS) and Air tables. The Monazite product is at present pumped to trench located in specified area for future use. Monazite is being a radioactive mineral in nature the processing area is protected by barricading for trespassers and the radiation level in the Monazite circuit at different level is monitored by the Health Physics Unit under BARC at OSCOM.

Zircon Circuit

The non conducting nonmagnetic fraction is then treated in Wet circuit consisting of Floatex density Separator, Spirals, Wet tables etc to separate Zircon and Sillimanite rich fraction from it. The heavier fraction of this circuit is mainly Zircon, which is dried in a Rotary Dryer followed by operation in HTS and Air table for further purification. Then the Zircon product is collected in hopper followed by bagging in 50kg bags in ware house.

Sillimanite Circuit

The lighter fraction in the wet circuit is mainly Sillimanite, which is separated from the unwanted quartz in froth flotation operation by using different chemicals like sodium silicate (depressant for quartz), soda ash (pH modifier), oleic acid (frother) etc. Finally the sillimanite is dried in a dryer followed by magnetic operation and stored in ware house. Apart from the above to support the dryers heating system, there is a furnace oil handling system consisting of a day tank capacity of 20KL and three screw pumps for pumping furnace oil to different dryers.

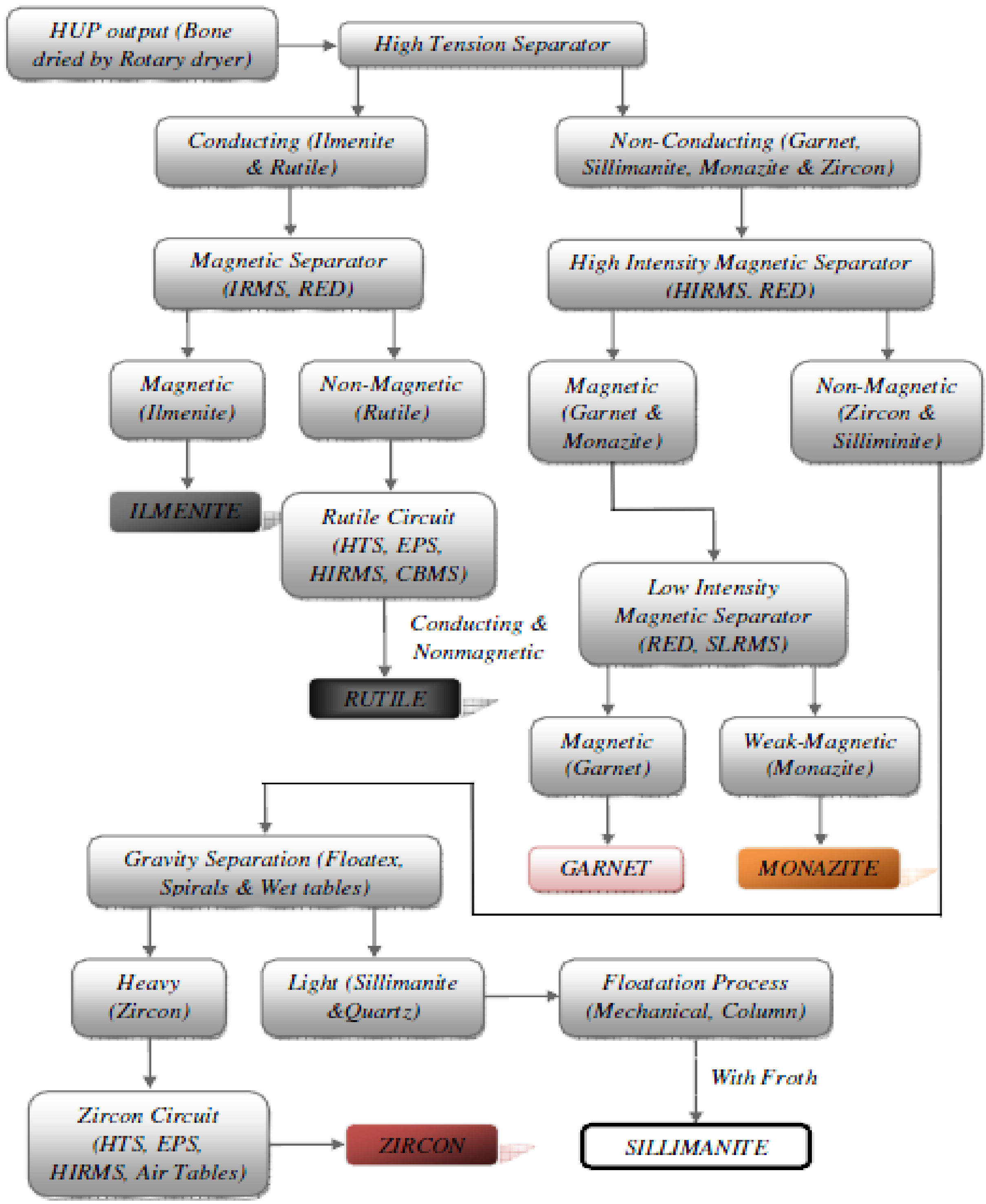

FIGURE -8: CIRCUITS FOR SEPARATION OF DIFFERENT MINERALS AT MSP

4.2. Equipments Used at MSP

Electrical Separators

Electrical separators utilize the difference in electrical conductivity between the various minerals in the ore feed. Since almost all minerals show some difference in conductivity it would appear to represent the universal concentrating method. The fact that the feed must be perfectly dry imposes limitations on the process, but it also suffers from the some disadvantage as, the capacity is very small for finely divided material. For most efficient operation, the feed should be in a layer, one particle deep, which severely restricts the throughput if the particles are as small as, say, 75 microns. In MSP, there are three different types of Electrical Separators which are being used depending upon the requirement.

High Tension Separator

High tension separator (HTS) utilizes the differences in surface conductivities of conducting and non conducting minerals thereby affecting their separation by pinning/lifting non conducting particles and throwing conducting particles with the help of electrodes. In MSP, HTS is used for the initial separation of conducting minerals from the non-conducting.

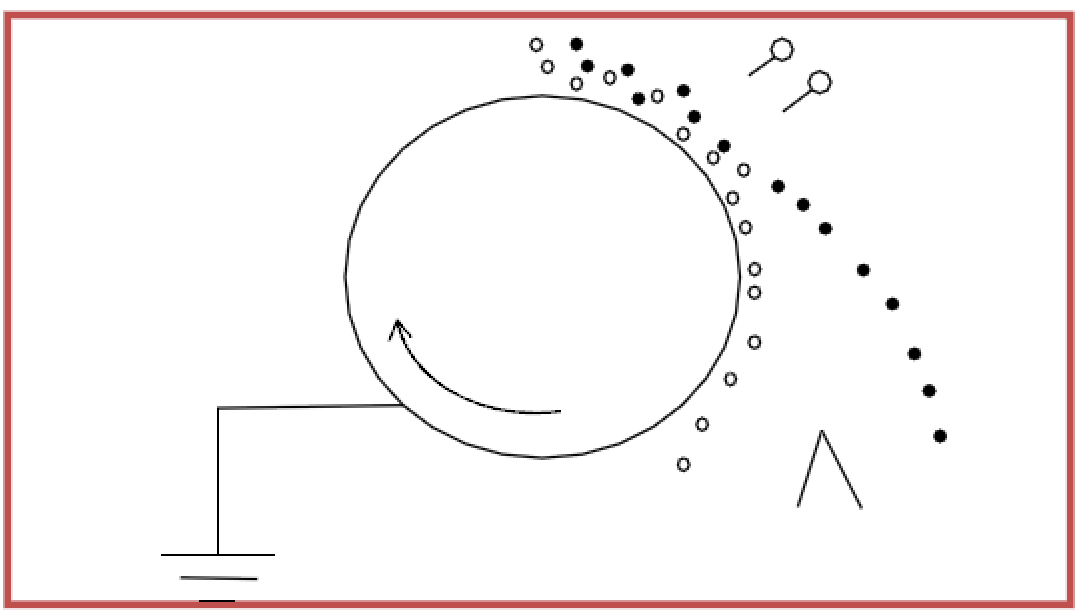

FIGURE-9: PRINCIPLE OF High Tension Separator

Electrostatic Separators

Final cleaning of the HTS products is often carried out in purely electrostatic separators, which employ the "lifting effect" only. The feed particles gravitate down a sloping, grounded plate into an electrostatic field induced by a large, oval, high-voltage electrode.

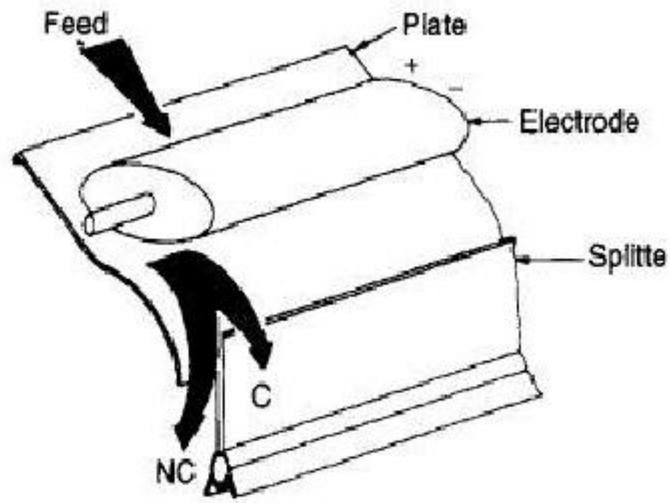

FIGURE -10: PRINCIPLE OF Electrostatic Separators

Coronastat Separator

It separates minerals based on their differences in surface conductivities using a unique combination of three electrodes. Each electrode has a unique function. The ionizing electrode ionizes the feed particles; the induction electrode forces the decay of charged conducting particles while the capacitance electrode applies a holding force to non-conducting particles as they travel through the separation zone, thus effecting the proper separation. The operating parameters are once again same as the HTS.

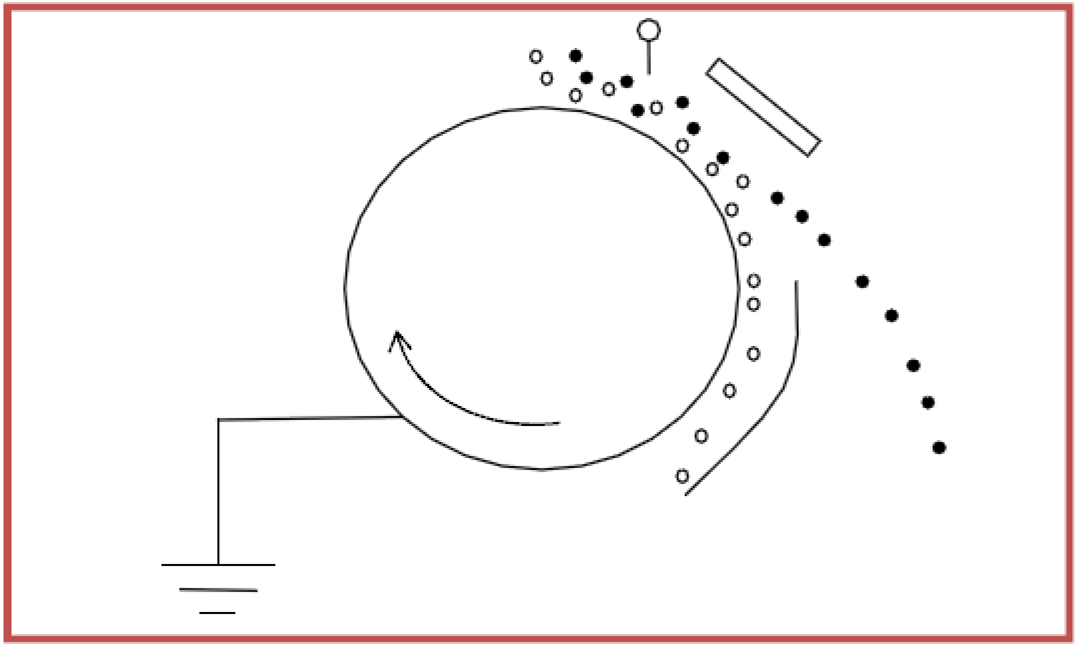

FIGURE -11: PRINCIPLE OF Coronastat Separator

There are five different types of magnetic separators used at MSP.

Induced Roll Magnetic Separators

Magnetic field is produced when an electric current (D.C.) is passed through a coil of wire (the induction process). The magnetic field intensity generated in an electro-magnetic separator is dependent upon:

- Amplitude of current (amps) – Variable
- Number of turns in coil (Windings) – Fixed
- The length of the iron circuit – Fixed
- Magnetic permeability of iron circuit (This includes the air gap in iron circuit necessary for separation zone)

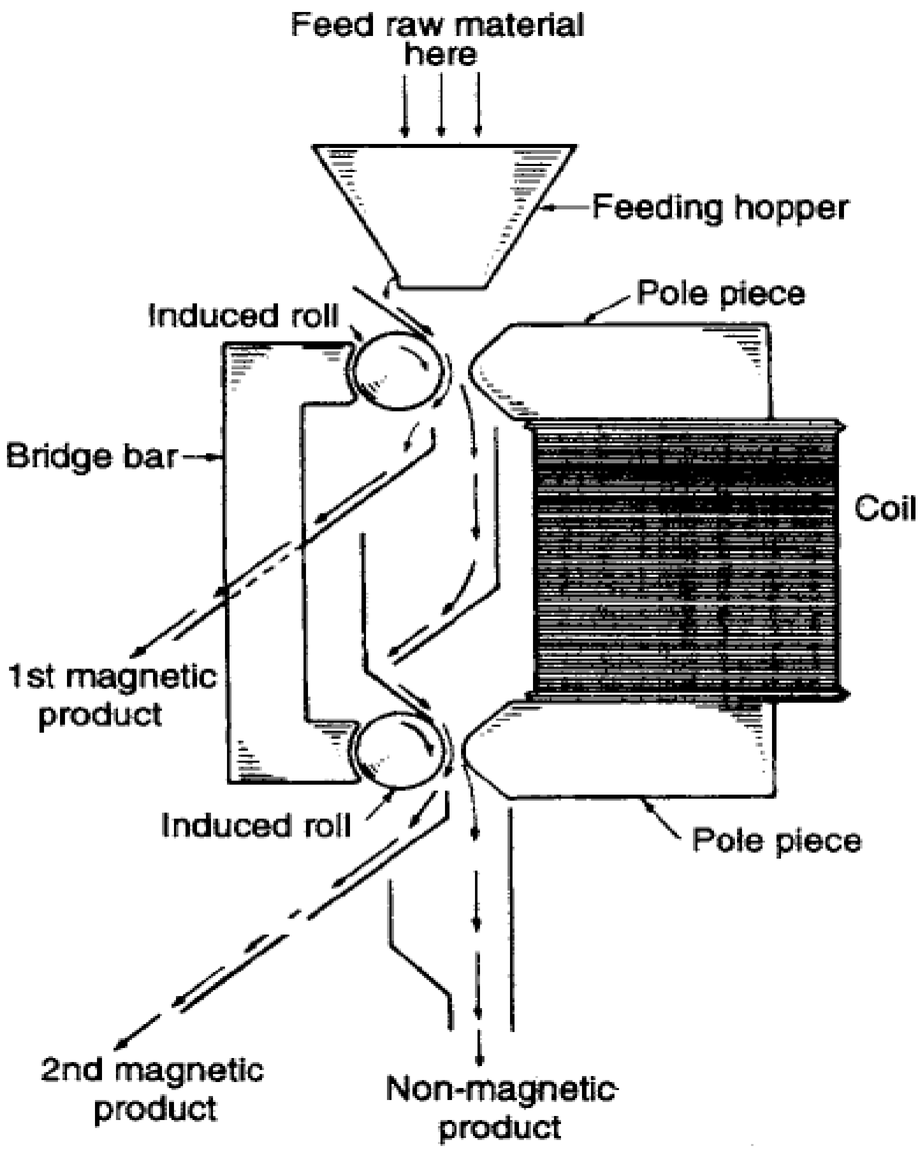

FIGURE -12: Induced Roll Magnetic Separators

The operating parameters are

- Magnetic field current
- Air gap
- feed rate
- roll speed
- splitter position

Generally feed rate is maintained at 4-5TPH per roll and the roll speed is around 150RPM.

Lift Roll & Semi Lift Roll Magnetic Separator

These are a different kind of magnetic separator where the magnetic particles are lifted by the roll under the action of magnetic field. It is used in Monazite circuit. These are high intensity magnetic separators to separate two or more variable magnetic susceptible minerals to separate as magnetic and non magnetic. These separators are used to separate Garnet from Monazite, Rutile from Leucoxene in beach sand minerals. The principle involved is the grounded roll is provided in between two magnetic blocks. The magnetic flux generated from the bottom of the roll directed towards upward direction. The roll having groove type surface, convergent magnetic field is generated around 19-10 Kilogauss is sufficient to lift Garnet particles from the monazite as garnet is moderately magnetic in nature and collected in the magnetic fraction. The feebly magnetic particles are collected in a separate chamber. The capacity of these separators is found to be 0.5 to 1.0 tons per hour for effective separation.

Rare earth Drum Magnetic Separators

Rare earth drum separator (REDS) is a kind of magnetic separator which separates the minerals on the basis of their difference in magnetic properties. It works on similar principle as the Induced roll magnetic separator but it differs in its basic construction and its operation. In this the magnetic field is produced by permanent magnets. The magnetic element is constructed with the help of blocks of Neodymium Iron Boron ceramic magnets, Iron or steel pole are not used in this configuration i.e. an ironless design. The magnetic element consists of five main magnetic poles; each pole consists of two magnetic blocks. There are also two trailing poles to provide "Diminishing" magnetic field intensity. This configuration generates a peak magnetic field intensity of 6-7 Kilogausses on the drum surface. The magnetic circuit remains stationary within the drum shell and spans an arc of approximately 1200. A single RED can treat up to 5 TPH effectively. A release mechanism is provided to dislodge minor amounts of ferromagnetic material from the drum surface.

The operating parameters are:

- feed rate
- roll speeds
- feed temperature
- splitter positions

Cross Belt magnetic Separators

It is a high intensity magnetic separator in which feed is allowed to pass through a main belt and a number of cross belts. Magnetic particles get attracted to the bottom part of the cross belt due to the influence of electromagnet placed over the cross belt which carries them out of magnetic field while non-magnetic particles pass on unaffected. The magnetic field is in the range of about 19-20 Kilogauss and the capacity is about 1.5-2.0TPH.

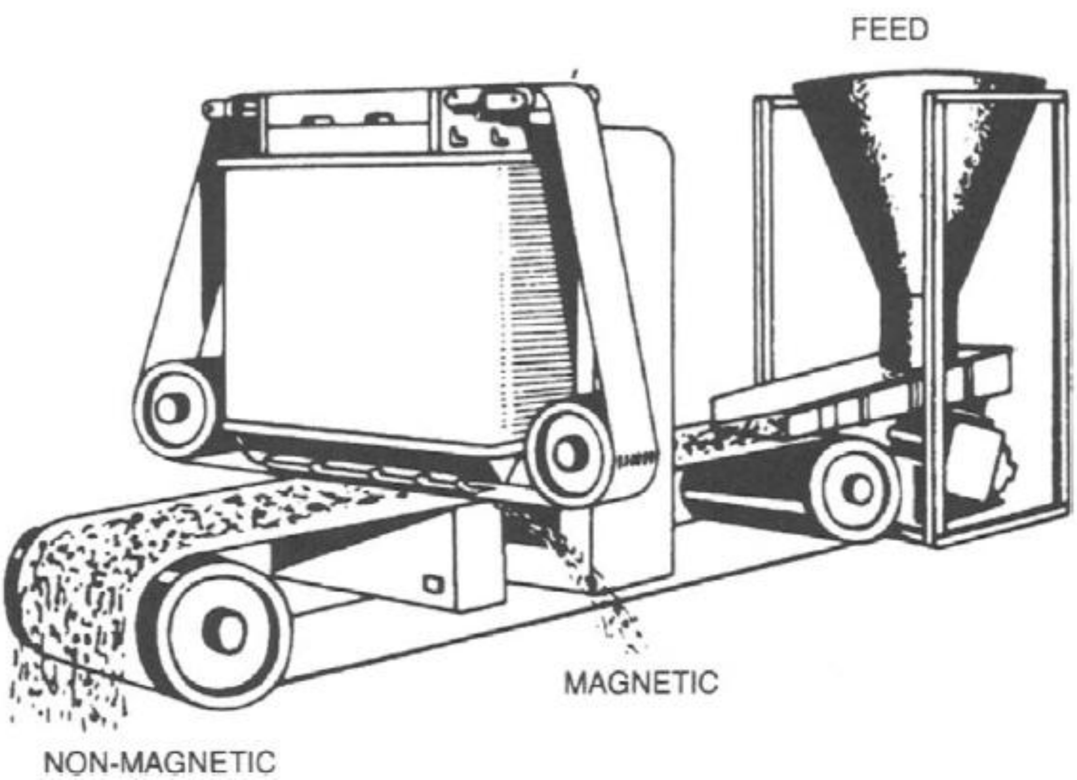

FIGURE -13: Cross Belt magnetic Separators

The operating parameters are:

- magnetic field current
- Air gap
- Belt speed
- feed rate

Gravity Concentrator

Gravity concentration methods separate minerals of different specific gravity by their relative movement in response to gravity and one or more other forces, the latter offers resistance to the motion by a viscous fluid, such as water or air. Different kinds of gravity concentrators are being used in MSP.

Wet Tables

Wet table consists of an inclined deck fitted with riffles. With given reciprocating motion at right angle to the flow of water, heavier minerals settle down in the riffles and concentrates are carried along the diagonal line of the table. The lighter minerals cannot settle in the riffles and are washed along with the water as tailings. The pulp density we generally maintain is 25-30% of solid.

The operating parameters are:

- quantity of wash water
- deck slope
- feed rate
- stoke length
- speed
- pulp density

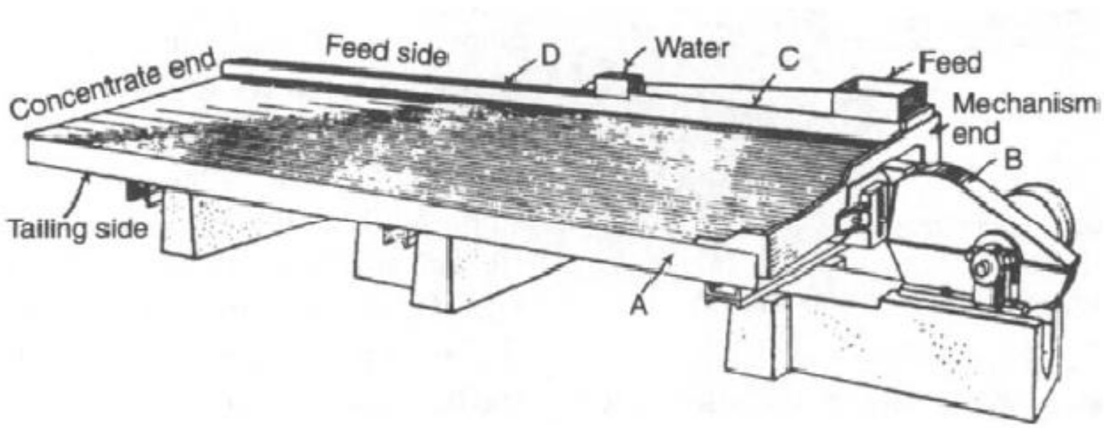

FIGURE -14: Wet Tables

Air Tables

Air tables are gravity concentrators which use air as a separating medium. Compressed air is allowed below the vibrating table whose surface is covered with a perforated cloth. The feed is supplied near the top of the inclined table. Lighter particle are lifted by the air and flow downwards as tailings. The oscillating motion of the table causes the heavy minerals in contact with the table surface to move upward and is collected as concentrate.

Operating parameters are:

- quantity of air
- feed rate
- deck inclination
- splitter opening
- stoke length
- speed

Floatex Density Separators

It is a hindered settling classifier and the material is classified on the basis of the settling velocity

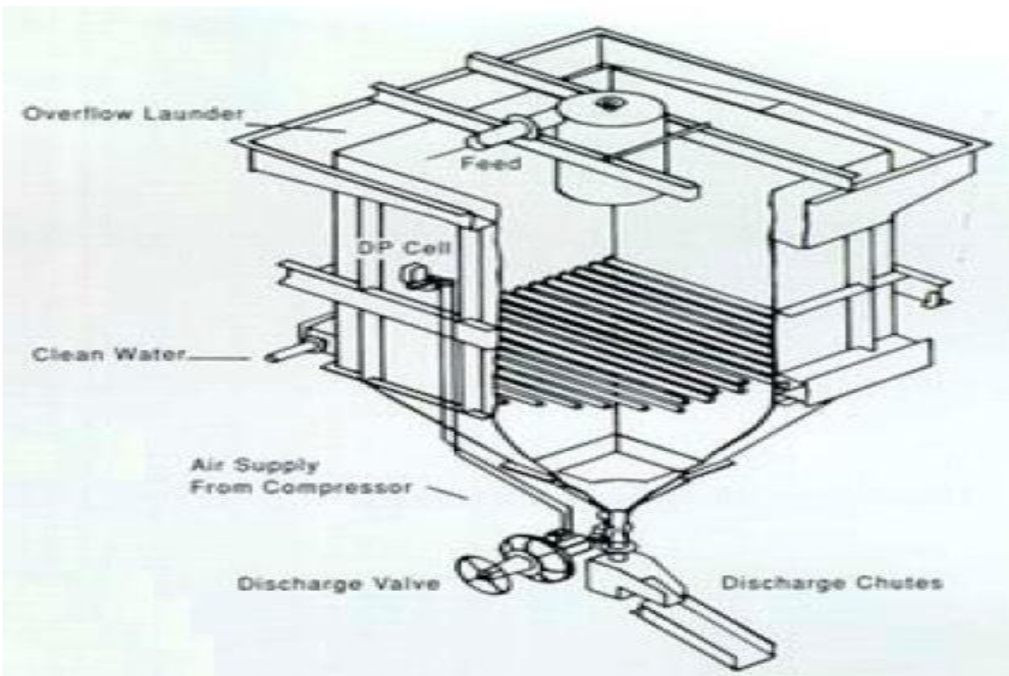

FIGURE -15: Floatex Density Separators

The principle employed by a floatex density separator is that when a rising current of water is introduced into the classifier over the whole of its area, the mineral expanded into a state teeter, in which the mineral particles classify themselves so that the coarser and heavier particles report to the bottom of the column where they relatively stay close to each other with high velocities of water flowing between them, while the finer and lighter particles will be dispersed to the higher levels of the column where they will stay in a more open suspension. Thus in a teetering column of sand the pulp gravity will be greater towards the bottom where the particles are laying closer to each other.

Hydrocyclones

Hydrocyclone is a classifying device that utilizes the centrifugal force to accelerate the settling rate of particles. A typical Hydrocyclone consists of a conically shaped container, open at its apex or underflow, connected to a cylindrical section, with a tangential feed inlet. The top opening is closed with the help of a plate through which passes an axially mounted overflow pipe. The feed is introduced under pressure through the tangential entry which imparts a swirling motion to the pulp. This generates a vortex in the cyclone, with a low-pressure zone along the vertical axis. An air core develops along the axis, normally connected to the atmosphere through the apex opening, but in part created by dissolved air coming out of solution in the zone of low pressure. Feed particles in the pulp are subjected to two opposing forces viz. an outward centrifugal force and an inward drag force. The centrifugal force causes coarse and heavy particles to report as underflow while the action of the drag force results in fine and light particles reporting as underflow.

The operating parameters are:

- feed inlet diameter
- spigot diameter
- vortex finder diameter
- feed pressure
- pulp density
- cut size

Flotation

Flotation is a process where the desired mineral particles in pulp are selectively floated by their attachment to rising bubbles. In MSP, slurry containing sillimanite and quartz is conditioned in the first stage with sodium silicate and soda ash.

Operating parameters are:

- slurry pH
- air pressure
- froth depth
- reagent dosage

- air flow
- feed rate
- Quantity of wash water
- conditioning time
- feed rate

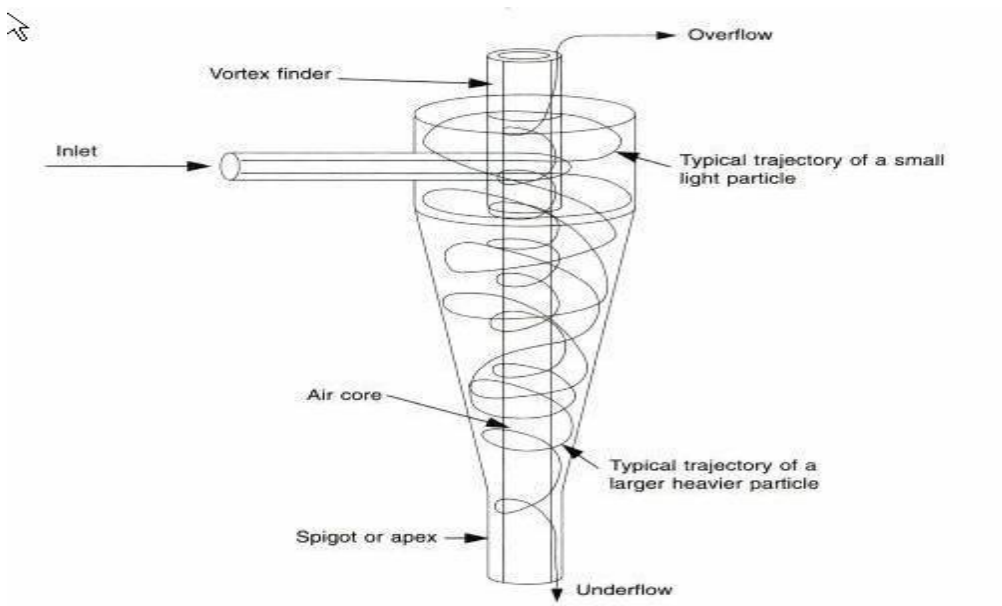

FIGURE -16: Hydrocyclones

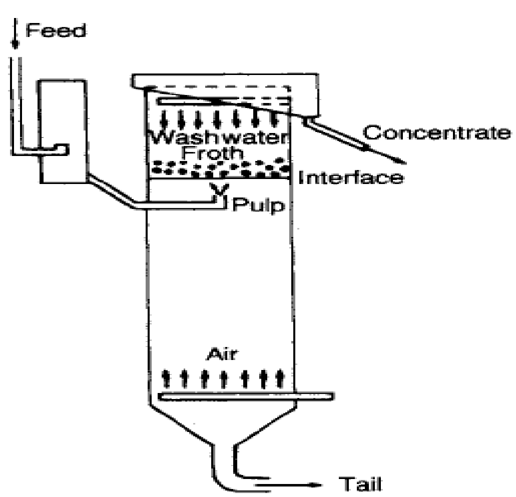

FIGURE -17: PROCESS OF Flotation

4.3. QUALITY CONTROL

Independent collection, suitable analysis, and reporting of final MSP product samples:

- Analysis and reporting for quality control of final Thorium plant product samples.
- Analysis of chemicals received at Central stores as per order for quality control.
- Technical Service is continuously checking for specification and the impurities present in the minerals before giving them confirmation for marketing.

TABLE -10: Specification and impurities content of the minerals before giving them confirmation for marketing

Minerals	Ilmenite	Rutile	Zircon	Garnet	Sillimanite
Product Specification (%)	98.5	97.5	97.5	94	92.5
Impurities in product (max %)	Gar-1 Mon-0.1	Zir-1.5 Mon-0.3	Sill-2, Rut-0.5 Mon-0.3	Ilm-4.0	Qtz-4 Mon-0.3
Guaranteed (minimum) for marketing	50.25% TiO_2	94.25% TiO_2	64.25 % ($ZrO_2 + HfO_2$)	94 % (Garnet)	56.5 % (Al_2O_3)

TABLE -11: Packaging and Pricing

Products	Price (Rs. / MT)	Packing
Rutile	41,000.00	50 Kg. bag
Zircon	40,000.00	50 Kg. bag
Ilmenite	5000.00	Loose
Sillimanite	12,000.00	Loose
Garnet	4000.00	Loose
Thorium Nitrate	4,30,000.00	50 Kg. Drum

CHAPTER V

SOFTWARE AND PROGRAM DEVELOPMENT

5.1. AIM

This program is encrypted having an intension of estimating the heavy mineral and the tailings generated in some processes with an approximate value before extraction which would help the authority to achieve production target and also provide cynosure for waste management.

This runs in Microsoft visual studio and coded in C# language.

5.2. ALGORITHM

Let dredged material input be x tons.

Percentage of heavy mineral content be y (14-18%).

DWUP

Let Trommel efficiency be z (i.e. 90-95%)

Trommel filter capacity quotient = 0.75.

Retained material or Output a is

Tailings, at is

Spirals

Let spiral efficiency be u (i.e. 95-98%)

Spiral filter capacity quotient = 0.35

Retained Material or output, b is

Tailings, bt is

Separators

Let separator efficiency be v (i.e. 99-100%)

Output, c is

Tailings, d is

Final Compositions

Ilmenite = c x 0.675

Rutile = c x 0.035

Zircon = c x 0.036

Monazite = c x 0.02

Silimanite = c x 0.07

Garnet = c x 0.155

Procedure

- Open Microsoft Visual Studio.
- Open Project “Project.sln”.
- Press F5 to execute.
- As the windows form appears, enter the inputs and click on “Calculate”.
- Next window opened will show the desired output.

5.3. CODES USED FOR THIS PROGRAM ARE GIVEN BELOW:

FOR FORM 1:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

namespace Project
{
```

```
public partial class Form1 : Form
{

    public Form1()
    {
        InitializeComponent();
    }



    private void button1_Click(object sender, EventArgs e)
    {
        double a, at, b, bt, c, d;
        double x= double.Parse(textBox1.Text);
        double y= double.Parse(textBox2.Text);
        double z= double.Parse(textBox3.Text);
        double u= double.Parse(textBox4.Text);
        double v= double.Parse(textBox5.Text);
        if (y==1)
            MessageBox.Show("UNECONOMICAL");
        if (z==9)
            MessageBox.Show("Repair Machine");
        if (u==9)
            MessageBox.Show("Repair Spiral");
        if ((v == 9) || (v == 1) || (v == 10))
            MessageBox.Show("Repair Separator");
        a = x - (x * 0.75 * z * 0.01);
        at = x - a;
        b = a - (a * 0.35 * u * 0.01);
        bt = a - b;
        c = (y - (0.05 * y)) * v * x * 0.01*0.01;
        d = b - c;
        Form2 f = new Form2(c,at,bt,d);
        f.Show();

    }

    private void textBox2_TextChanged(object sender, EventArgs e)
```

```
{
    double y = double.Parse(textBox2.Text);
    if (y == 1)
    { }

    else if (y < 14)
        MessageBox.Show("UNECONOMICAL");
    else if (y > 18)
        MessageBox.Show("Invalid Input!");

}

private void textBox3_TextChanged(object sender, EventArgs e)
{
    double z = double.Parse(textBox3.Text);
    if (z == 9)
    { }
    else if (z < 90)
        MessageBox.Show("Repair Machine");
    else if (z > 95)
        MessageBox.Show("Invalid Input");
}

private void textBox4_TextChanged(object sender, EventArgs e)
{
    double u = double.Parse(textBox4.Text);
    if (u == 9)
    { }
    else if (u < 95)
        MessageBox.Show("Repair Machine");
    else if (u > 98)
        MessageBox.Show("Invalid Input");
}

private void textBox5_TextChanged(object sender, EventArgs e)
{
    double v = double.Parse(textBox5.Text);
    if ((v == 9)||(v==1)||(v==10))
    { }
```

```
            else if (v < 99)
                MessageBox.Show("Repair Machine");
            else if (v > 100)
                MessageBox.Show("Invalid Input");
        }

    }
}
```

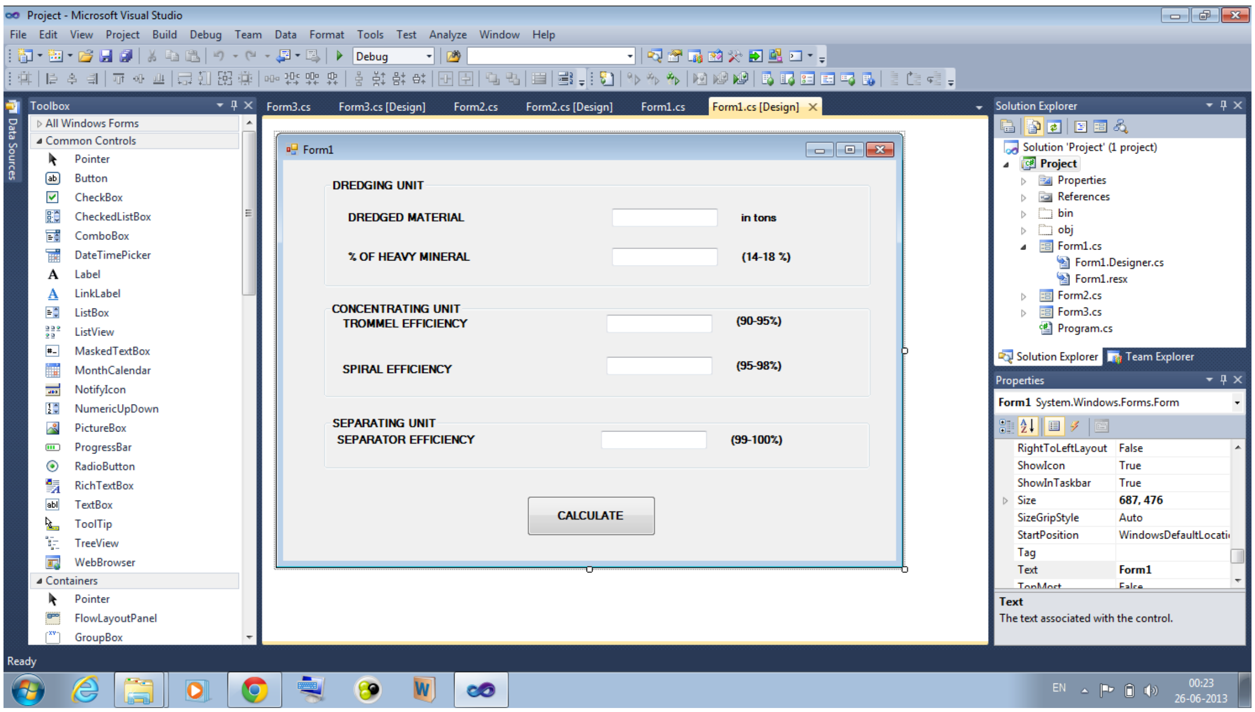

FIGURE-18: VIEW OF FORM 1

FOR FORM 2:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

namespace Project
```

```
{
    public partial class Form2 : Form
    {
        double x,l,m,n;
        public Form2(double c,double at, double bt, double d)
        {
            x = c;
            l = at;
            m = bt;
            n = d;
            InitializeComponent();
        }
        public Form2()
        {
        }

        private void Form2_Load(object sender, EventArgs e)
        {
            textBox1.Text = Convert.ToString(x * 0.675);
            textBox2.Text = Convert.ToString(x * 0.035);
            textBox3.Text = Convert.ToString(x * 0.036);
            textBox4.Text = Convert.ToString(x * 0.02);
            textBox5.Text = Convert.ToString(x * 0.07);
            textBox6.Text = Convert.ToString(x * 0.155);
        }

        private void button1_Click(object sender, EventArgs e)
        {
            Form3 f1 = new Form3(l, m, n);
            Form2 f4 = new Form2();
            f1.Show();
            f4.Hide();
        }

    }
}
```

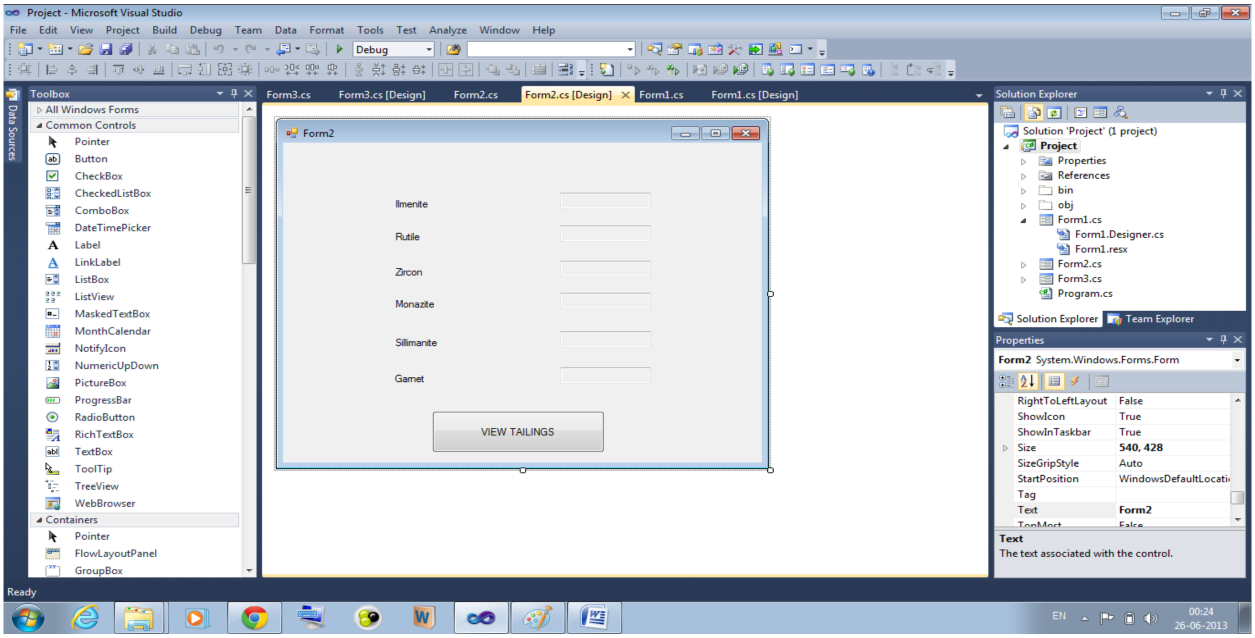

FIGURE-19: VIEW OF FORM 2

FOR FORM 3:

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;

namespace Project
{
    public partial class Form3 : Form
    {
        double p, q, r;
        public Form3(double l,double m,double n)
        {
            p = l;
            q = m;
            r = n;
            InitializeComponent();
        }
```

```
        public Form3()
        {
        }
        private void Form3_Load(object sender, EventArgs e)
        {
            textBox1.Text = Convert.ToString(p);
            textBox2.Text = Convert.ToString(q);
            textBox3.Text = Convert.ToString(r);
        }

        private void button1_Click(object sender, EventArgs e)
        {
            Form1 f2 = new Form1();
            f2.Show();
            Form3 f3 = new Form3();
            f2.Show();
            f3.Hide();
        }
    }
}
```

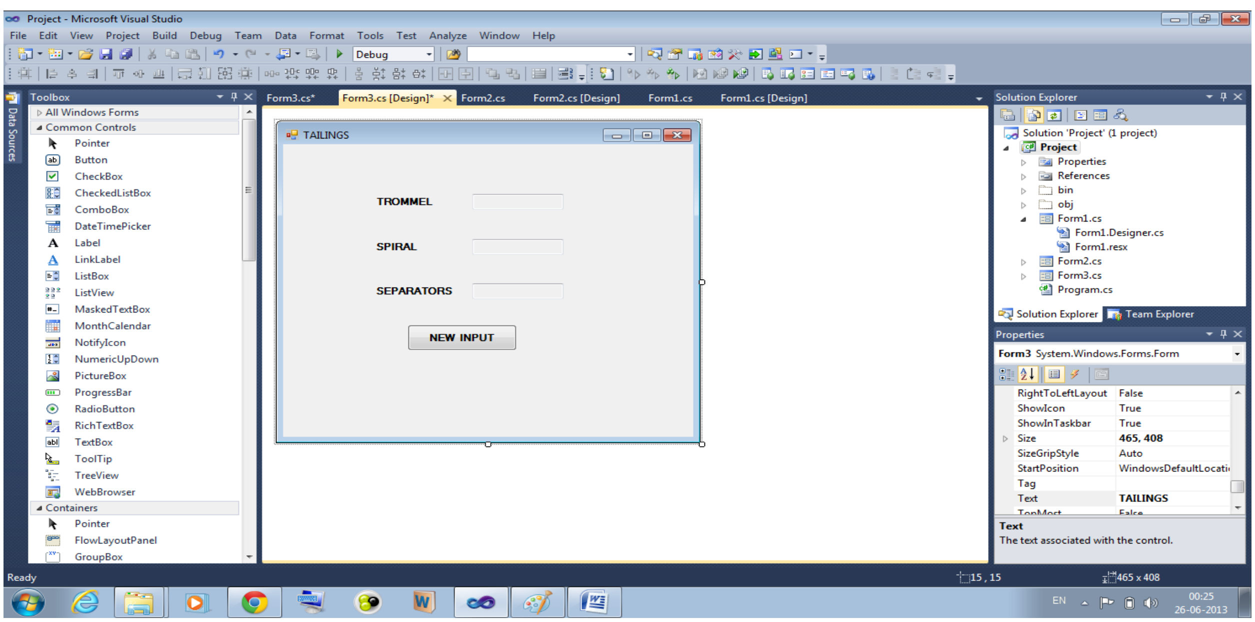

FIGURE-20: VIEW OF FORM 3

CHAPTER VI

USES AND APPLICATIONS OF HEAVY MINERALS

6.1. Uses of different products

Ilmenite & Rutile:

- *As Titanium (TiO2) white pigment:* Used in Paints/ Varnishes, Plastic, Paper, Rubber, Printing ink, coated fabric textiles, Cosmetics, sun protection creams and Pharmaceuticals.
- *As Titanium (Ti) sponge/metal:* Used in Chemical industry, Aerospace & Aviation industry, Surgical equipments, Electrical turbines tubing, Bullet proof vests, Different alloys in Iron & steel industry, Immersion heater tubes, Consumer goods, Spectacle frames, Golf clubs.
- Used for coating of welding electrodes.

Zircon:

- Used in Ceramics, Foundries, Refractories, Glazing tiles, Television and Computer monitors and White wars.
- It is also used in manufacture of Zirconium chemicals/metal, American diamond, Scratch free bracelets, Cutting tools, Yttria Zirconia as oxygen sensors. Zircon free from Hafnium is used in nuclear reactors as cladding tubes to hold nuclear fuel.

Sillimanite:

- Mainly used for the manufacture of High grade refractory bricks, high Alumina Refractories, Cement kilns and Heat treatment furnaces.

Garnet:

- Used for manufacture of Blasting media, Abrasives, Grinding wheels, Mosaic cutting stones, Decorative wall plasters, Ceramics, Polishing of picture tubes, Glass polishing & Antiskid surface for roads, air strips, runways, water filter, water jet cutting,

- Artificial Granite tiles/Heavy duty floor tiles, cleaning of casings/pipes in petroleum industry and as a gemstone.

Monazite:

- Extraction of thorium concentrate and rare earth compounds.
- **Rare earth chlorides**: Widely used in the manufacture of Misch metal used for lighter flints, for the production of catalysts for cracking, for the manufacture of metallic soaps which is used as Dryer in paints, starting material for the production of pure rare earths & rare earth compounds, removal of organic impurities and decolourisation of paper mills effluents and for the manufacture of special ferrous casting.
- **Rare earth Fluorides**: Used in manufacture of arc carbon electrodes to increase the arc intensity, rare earth alloys, for production of nodular cast iron, special steels.
- **Rare earth Oxides:** In the arc carbon industries to increase the arc intensity by factor ten, the emitted light is identical to natural sun light, for glass polishing in Optical.
- **Cerium oxide:** Used in Polishing optical lenses, plate glasses, TV tube face plates; prism etc. finds application in semiconductor devices, UV absorber in Glasses, radiation protective glasses, yellow color and decolorizing etc.
- **Cerium hydrates**: Used in manufacture of polishing composition, in the decolorizing of glass, as an opacifier, as an ingredient in Ultraviolet.
- **Didymium compound:** Use in manufacture of pure rare earth compound, in glass, ceramics, and nuclear & electronic industries and for improving the workability of stainless steel alloys.
- **Samarium oxide:** For the extraction of samarium metal this finds use in manufacture of **samarium cobalt**; used as permanent magnet with high coercive force and high magnetic energy.
- **Gadolinium oxide:** In the manufacture of Gadolinium-Gallium-Garnet (GGG) substrates of magnetic bubbles and Microwave garnets.
- **Yttrium oxide:** In the manufacture of phosphor for color tubes and Fluorescents tubes, super conductors and artificial gems.

- **Europium oxide:** As an activator in preparing phosphors for color TV tubes & fluorescent lamps.
- **Europium:** Three bond lamps, cathode ray tubes (CRT), flat plasma TV screen and phosphors.
- **Terbium:** Luminescence, phosphors.
- **Dysprosium:** Luminescence, phosphors, application for nuclear industry, ceramics.
- **Holmium:** Application for nuclear industry, ceramics, laser.
- **Erbium:** Nuclear reactors, ceramics, glass coloring, optic fibers, medical applications, laser.
- **Thorium Nitrate:** Gas handling Industry
- **Thorium Oxide:** Fluorescence tubes & starters; Catalyst for Petroleum industry
- **Uranium Oxide:** Nuclear Industry
- **Tri sodium phosphate:** Descaling, Degreasing, Detergents.

CHAPTER VII

IMPEDIMENTS AND ADVANTAGES

7.1. IMPEDIMENTS OF PLACER MINING

- Land Acquisition is an issue. The area under lease has decreased owing to various social & environmental issues.
- These minerals are strategic assets. Secrecy is maintained according to shipment and production data.
- The CRZ notification has further divested IREL for carrying out dredging activities within 100 meters of the High Tide Line.
- Fresh water availability for the artificial pond is minimized.
- Dredging creates disturbances to the aquatic ecosystems. Dredge spoils may contain toxic chemicals which have an adverse impact on the disposal area; The process of dredging often dislodges chemicals residing into the water column.

The following impacts to the environment due to the activity of dredging :

- Release of toxic chemicals like heavy metals and PCB
- Increase in turbidity, which affects aquatic species metabolism
- Secondary effects from water column contamination of uptake of DDT ,heavy metals, other persistent organic toxins, via food chain uptake and concentrations of these toxins in higher organisms including humans.
- Difficulty in marsh productivity from sedimentation
- Impacts to avifauna as they have to prey upon contaminated aquatic organisms
- Secondary impacts to the aquatic and benthic organisms' mortality and metabolism.

7.2. ADVANTAGES OF PLACER MINING

- Processing and transport cost is reduced up to 40-50% as these are loose materials.
- Safety issues are not major as compared to underground mining.
- The deposits in Orissa were very old; however in Kerala and Kanyakumari, still the deposits are being readily formed and extracted by beach washing.

CHAPTER VIII

8.0. CONCLUSION

Indian Rare Earths Ltd. is one among the public sector, which has an outstanding performance in the processing of beach sand minerals available along the coastal belt. The organization study in this unit is an unforgettable experience. The work culture is gratifying and also the concern for safety, environment issues and the social responsibility prevailed in this organization is worth studying.

This study helped me in having a pragmatic exposure to mining as well as processing activities of the sand mining organizations. With the advent of technology and monotonically increasing metal prices across the world, it is expected that study of placer and seabed mining would be the need of the future as these resources are largely remained untapped.

It is desirable that the government should take adequate steps for proper exploitation and utilization of these resources. With the amount of talent bank available in India, new advances can be made in the mining as well as processing technology of placer minerals it can be assured that the costs of these minerals would come down.

SCOPE FOR FURTHER STUDY

Due to limited time given for this project detailed cost accounting part is not covered which can be taken up for further study in future.

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